

THAT WHICH IS CLAIMED:

1. A method for manufacturing a friction welded, expanded structural assembly, the method comprising:

positioning at least two structural members in a stacked relationship with at least one elongate member disposed between the structural members, each elongate member extending generally along a path of at least one cell of the structural assembly and defining a passage therealong;

friction stir welding the structural members in a predetermined pattern to form a preform defining the cell therebetween, the elongate member having a width smaller than a width of the cell such that the elongate member maintains the passage between the structural members generally along the path of the cell; and

inflating the cell with a pressurized fluid in the passage of the cell to expand the preform to a desired configuration of the structural assembly.

2. A method according to Claim 1 wherein said positioning step comprises positioning at least one core member between first and second face members such that the first and second face members are directed toward opposite surfaces of the core member.

3. A method according to Claim 2 wherein said friction stir welding step comprises friction stir welding the first face member to the core member with a friction stir welding tool that penetrates the first face member and at least a portion of the core member such that the welding tool does not penetrate the second face member, and friction stir welding the second face member to the core member with a friction stir welding tool that penetrates the second face member and at least a portion of the core member such that the tool does not penetrate the first face member.

4. A method according to Claim 2 wherein said friction stir welding step comprises friction stir welding a plurality of the core members such that the core members are joined by friction stir weld joints disposed entirely within the core members and the first and second face members are configured to be inflated away from the core members.

5. A method according to Claim 4 further comprising disposing at least one elongate member between the core members before friction stir welding the core members, the elongate member extending generally along a path of at least one cell of the structural assembly.
6. A method according to Claim 2 wherein said inflating step comprises expanding a plurality of cells, at least some of the cells of the preform being inflated to six-sided shapes extending in a longitudinal direction such that the cells of the structural assembly define a honeycomb configuration.
7. A method according to Claim 2 further comprising welding a periphery of the preform to define at least one fluid inlet in fluid connection with the cells.
8. A method according to Claim 7 wherein said step of welding the periphery of the preform comprises friction stir welding the periphery of the preform with a rotating friction stir welding tool that at least partially penetrates each of the first and second face members.
9. A method according to Claim 1 wherein said friction stir welding step comprises forming a multiple-pass friction stir weld joint having at least two adjacent friction stir weld joints between adjacent cells.
10. A method according to Claim 9 wherein said friction stir welding step comprises forming the adjacent friction stir weld joints of the multiple-pass friction stir weld joint with a combined width greater than a thickness of each of the structural members.
11. A method according to Claim 9 wherein said friction stir welding step comprises forming each multiple-pass friction weld joint with the adjacent weld joints, at least one of the adjacent weld joints having a nonlinear configuration.
12. A method according to Claim 1 wherein said inflating step comprises positioning the preform in a die cavity defining a contour surface corresponding to a desired contour of the structural assembly and expanding the cells to urge the structural members outward against the die cavity.

13. A method according to Claim 12 further comprising providing at least one die defining the die cavity, the contour surface defining a complex curve such that said inflating step comprises forming the structural assembly to define the complex curve of the contour surface.
14. A method according to Claim 1 further comprising heating the preform to a superplastic forming temperature such that the preform is superplastically formed during said inflating step.
15. A method according to Claim 1 further comprising circulating a coolant fluid through the structural assembly after said inflating step, thereby quenching the structural assembly.
16. A method according to Claim 1 wherein said inflating step comprises cold stretch forming the preform.
17. A method according to Claim 1 further comprising providing the structural members, at least one the structural members comprising aluminum.
18. A method according to Claim 1 further comprising removing the elongate members from the structural assembly after said inflating step.
19. A method according to Claim 1 further comprising providing a braze material between the structural members and melting the braze material to substantially seal the weld joints formed by said friction stir welding step.
20. A friction welded preform for forming an expanded structural assembly, the preform comprising:
  - at least two structural members in a stacked relationship;
  - a plurality of friction stir weld joints connecting the structural members such that the structural members define at least one cell between the friction stir weld joints;
  - a weld joint extending at least partially around a periphery of the structural members and defining a fluid inlet fluidly connected to the cell such that the preform is configured to be expanded by a pressurized fluid injected through the fluid inlet and into the cells; and

at least one elongate member disposed between the structural members and extending generally along a path of the cell, the elongate member having a width smaller than a width of the cell such that the elongate member maintains a passage between the structural members along the path of the cell.

21. A preform according to Claim 20 wherein the preform comprises first and second face members and at least one core member therebetween, at least one elongate member being disposed between the core member and the first face member and at least one elongate member being disposed between the core member and the second face member, the elongate members extending generally along a path of a plurality of cells of the structural assembly.

22. A preform according to Claim 21 wherein first friction stir weld joints extend between the first face member and at least a portion of the core member and second friction stir weld joints extend between the second face member and at least a portion of the core member, such that the first friction stir weld joints are configured to be inflated away from the second face member and the second friction stir weld joints are configured to be inflated away from the first face member.

23. A preform according to Claim 20 wherein the preform comprises first and second face members and a plurality of core members therebetween, at least some of the friction stir weld joints being disposed entirely between the core members such that the first and second face members are configured to be inflated away from the core members.

24. A preform according to Claim 20 wherein the preform defines multiple-pass friction stir weld joints having at least two adjacent friction stir weld joints between adjacent cells.

25. A preform according to Claim 24 wherein the adjacent friction stir weld joints of the multiple-pass friction stir weld joints have a combined width greater than a thickness of each of the structural members.

26. A preform according to Claim 20 wherein at least one the structural members comprises aluminum.

27. A preform according to Claim 20 further comprising a braze material disposed between the structural members, the braze material being characterized by a melting temperature that is lower than a melting temperature of the structural members such that the braze material is configured to be melted between the structural members.

28. A method for manufacturing a friction welded, expanded structural assembly, the method comprising:

positioning at least two structural members in a stacked relationship;

friction stir welding the structural members in a predetermined pattern to form a preform defining at least one cell therebetween; and

inflating the cell with a pressurized fluid to expand the preform to a desired configuration of the structural assembly,

wherein said friction stir welding step comprises forming a plurality of multiple-pass friction stir weld joints having at least two adjacent friction stir weld joints between adjacent cells of the preform such that the adjacent friction stir weld joints of each multiple-pass friction stir weld joint have a combined width greater than a width of each of the adjacent friction stir weld joints taken individually.

29. A method according to Claim 28 wherein said positioning step comprises positioning at least one core member between first and second face members such that the first and second face members are directed toward opposite surfaces of the core member, and wherein said friction stir welding step comprises friction stir welding the first face member to the core member with a friction stir welding tool that penetrates the first face member and at least a portion of the core member such that the welding tool does not penetrate the second face member and friction stir welding the second face member to the core member with a friction stir welding tool that penetrates the second face member and a portion of the core member such that the tool does not penetrate the first face member.

30. A method according to Claim 29 wherein said friction stir welding step comprises friction stir welding a plurality of the core members such that the core members are joined by friction stir weld joints disposed entirely within the core members and the first and second face members are configured to be inflated away from the core members.

31. A method according to Claim 29 wherein said inflating step comprises expanding a plurality of cells, at least some of the cells of the preform being inflated to six-sided shapes extending in a longitudinal direction such that the cells of the structural assembly define a honeycomb configuration.
32. A method according to Claim 29 further comprising welding a periphery of the preform to define at least one fluid inlet in fluid connection with the cells.
33. A method according to Claim 32 wherein said second welding step comprises friction stir welding the periphery of the preform with a rotating friction stir welding tool that at least partially penetrates each of the first and second face members.
34. A method according to Claim 28 wherein said friction stir welding step comprises forming the adjacent friction stir weld joints with a combined width greater than a thickness of each of the structural members.
35. A method according to Claim 28 wherein said inflating step comprises positioning the preform in a die cavity defining a contour surface corresponding to a desired contour of the structural assembly and expanding the cells to urge the structural members outward against the die cavity.
36. A method according to Claim 35 further comprising providing at least one die defining the die cavity, the contour surface defining a complex curve such that said inflating step comprises forming the structural assembly to define the complex curve of the contour surface.
37. A method according to Claim 28 further comprising heating the preform to a superplastic forming temperature such that the preform is superplastically formed during said inflating step.
38. A method according to Claim 28 further comprising circulating a coolant fluid through the structural assembly after said inflating step, thereby quenching the structural assembly.

39. A method according to Claim 28 wherein said inflating step comprises cold stretch forming the preform.
40. A method according to Claim 28 further comprising providing the structural members, at least one of the structural members comprising aluminum.
41. A method according to Claim 28 wherein said friction stir welding step comprises forming each multiple-pass friction weld joint with the adjacent friction stir weld joints, at least one of each adjacent friction stir weld joint of each multiple-pass friction weld joint having a nonlinear configuration.
42. A method according to Claim 28 further comprising providing a braze material between the structural members and melting the braze material to substantially seal the weld joints formed by said friction stir welding step.
43. A friction welded, expanded structural assembly comprising:  
at least two expanded structural members in a stacked relationship; and  
a plurality of friction stir weld joints connecting the structural members such that the structural members define a plurality of cells between the friction stir weld joints, the friction stir weld joints at least partially defining the cells;  
wherein a multiple-pass friction stir weld joint having at least two adjacent friction stir weld joints is disposed between adjacent cells, the adjacent friction stir weld joints of each multiple-pass friction stir weld joint having a combined width greater than a width of each of the adjacent friction stir weld joints taken individually.
44. A structural assembly according to Claim 43 wherein the structural assembly comprises first and second face members and at least one expanded core member therebetween, the assembly defining cells between the core member and each of the first and second face members.
45. A structural assembly according to Claim 43 wherein first friction stir weld joints extend between the first face member and at least a portion of the core member and second friction stir weld joints extend between the second face member and a portion of the core

member, the assembly defining cells between the first friction stir weld joints and the second face member and between the second friction stir weld joints and the first face member.

46. A structural assembly according to Claim 43 wherein the structural assembly comprises first and second face members and a plurality of core members therebetween, at least some of the friction stir weld joints being disposed entirely between the core members such that the structural assembly defines cells between the core members and the first and second face members.

47. A structural assembly according to Claim 43 wherein at least one the structural members comprises aluminum.

48. A structural assembly according to Claim 43 wherein the multiple-pass friction stir weld joint includes adjacent friction stir weld joints, at least one of the adjacent friction stir weld joints having a nonlinear configuration.

49. A structural assembly according to Claim 43 further comprising a braze material disposed between the structural members and substantially sealing the friction stir weld joints.

50. A friction welded, expanded structural assembly comprising:  
a core having at least four expanded core members joined by a first plurality of elongate friction stir weld joints, each elongate friction stir weld joint extending between an adjacent pair of the core members such that each adjacent pair of the core members defines a plurality of cells therebetween, each cell extending between adjacent friction stir weld joints;  
and

first and second face members friction stir welded to opposite sides of the core by a second plurality of elongate friction stir weld joints such that each face member and the core define a plurality of cells therebetween.

51. A structural assembly according to Claim 50 wherein at least one the structural members comprises aluminum.

52. A method for manufacturing a friction welded, expanded structural assembly, the method comprising:
- positioning at least three structural sheets to define first and second face members with at least one core member therebetween in a stacked relationship;
  - disposing elongate members between the sheets at predetermined locations;
  - friction stir welding the sheets in a predetermined pattern to form a preform, the elongate members defining a plurality of passages between the sheets for receiving a pressurized fluid;
  - providing the pressurized fluid to the passages defined between the sheets to form inflated cells corresponding to the location of the elongate members between the sheets, thereby expanding the assembly to a desired configuration; and
  - removing the elongate members from the structural assembly after said inflating step.
53. A method according to Claim 52 wherein said friction stir welding step comprises friction stir welding the first face member to the core member with a friction stir welding tool that penetrates the first face member and at least a portion of the core member such that the welding tool does not penetrate the second face member, and friction stir welding the second face member to the core member with a friction stir welding tool that penetrates the second face member and at least a portion of the core member such that the tool does not penetrate the first face member.
54. A method according to Claim 52 further comprising friction stir welding a periphery of the preform with a rotating friction stir welding tool that at least partially penetrates each of the first and second face members to define at least one fluid inlet in fluid connection with the cells.
55. A method according to Claim 52 wherein said friction stir welding step comprises forming a multiple-pass friction stir weld joint having at least two adjacent friction stir weld joints between adjacent cells.
56. A method according to Claim 55 wherein said friction stir welding step comprises forming the adjacent friction stir weld joints of the multiple-pass friction stir weld joint with a combined width greater than a thickness of each of the structural members.

57. A method according to Claim 52 further comprising heating the preform to a superplastic forming temperature such that the preform is superplastically formed during said providing step.

58. A method according to Claim 52 wherein said providing step comprises cold stretch forming the preform.

59. A method according to Claim 52 further comprising providing the structural members, at least one the structural members comprising aluminum.

60. A method according to Claim 52 further comprising providing a braze material between the structural members and melting the braze material to substantially seal the weld joints formed by said friction stir welding step.